In re Patent Application of:
DEANE ET AL.
Serial No. **10/775,395**
Filed: **02/10/2004**

REMARKS

Claims 1-20 are pending in this application.

Claims 10, 18, and 19 are withdrawn from consideration.

Claims 1-9, 11-17 and 20 are rejected under 35 U.S. C. 103 (a) as being unpatentable over Heflinger et al US 4,893,403, and further in view of Rinne US 6,418,033.

The examiner states that "Helfinger et al disclose a method of bonding an element to a substrate comprising the steps of providing a substrate, placing solder bumps on either the element or the substrate, determine the shape size and location of the solder pad, and heating the solder bumps in the absence of any further supporting or orienting of the element to cause a flow of the solder bumps (col. 1 lines 10-69)."

The examiner states that "Heflinger et al disclose the claimed invention above, but lack the mention of arranging the chip and the substrate at an angle greater than 0 but less than 90 degrees, pads are symmetric about two orthogonal axes, and bumps are secured thereto in an asymmetrical fashion."

Col. 1 lines 10-69 of Helfinger describe the background of the art.

On col. 1 lines 10-24 the general idea of solder bumps is described. On col.1 lines 26 through 34, US patent 4,558,812 is described which relates to a method of providing solder

bumps on pads of a chip. A more detailed description of the process of providing solder bumps on the chip is found in the abstract of U.S. patent 4,558,812 is shown here:

> Chip carriers (10--10) are released from an end of a dispensing means (38) drawn across a holder (22) having a plurality of apertures (28--28) therein, to place a carrier in each aperture. Small solder spheres (58--58) are located in a plurality of dimples (56--56) of a planar plate (40) in arrays that are substantially the same as a plurality of bonding pad arrays (18--18) on the bottom surface of a plurality of chip carriers. A vacuum is applied to the holder (22) to hold the chip carriers (10--10) in the apertures (28--28) as the holder rotates to place the bonding pads (18--18) in contact with the solder spheres (68--68). The solder spheres (58--58) are reflowed by applying heat to form a solder "bump" (68) on each pad (18). The chip carriers (10--10) are then cooled and loaded into a plurality of the tubular members (39--39).

Further on col. 1 lines 10-69 more particularly lines 35-40 there is a description of US patent 2,097,986 to R. Henry et al wherein a diode is bonded to a thin substrate.

On col. 1, beginning at line 41 there is description of a chip aligned by means of a beam splitter cube, inserted between the chip and a circuit board. The board was moved until the images of the chip's solder bump pattern and the circuit boards solder bump pattern coincided. The beamsplitter was moved out of the way and the chip lowered onto the circuit board.

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Col 1 lines 56 through 69 discuss the problem with removing a single chip on a board or substrate for replacement, if defective or in the even of chip failure. It is a goal of cited US Patent 4,893,403 as described lines 56 through 69 to reseating a chip for direct joinder onto a circuit board or substrate without modification of the substrate and without special holders for the chips.

The applicant has recited these descriptions found in col.1 lines 10-69 as there is no correspondence with any of these teachings and the invention recited in the applicant's claims, with the exception of solder bumps being a common subject.

It is said in the office action that Helfinger et al disclose a method of bonding an element to a substrate comprising the steps of providing a substrate, placing solder bumps on either the element or the substrate, determine the shape, size and location of the solder pad, and heating the solder bumps in the absence of any further supporting or orienting of the element to cause a flow of the solder bumps (col. 1, lines 10-69).

It should be noted that Helfinger does not disclose the method described above by the examiner. For example the words size or shape do not appear in the Helfinger specification. Furthermore there is no mention of the solder bumps in the absence of any further supporting or orienting of the element to cause a flow of the solder bumps; and more importantly the specific steps of first heating to tack the element in a first position followed by reheating to cause a predetermined

tilting displacement of the element into a predetermined position by heating alone without any further support simply is not suggested. This embodiment is now clearly defined in claim 9.

Claim 1 of the instant invention defines:

A method of bonding an element to a substrate, the method comprising the steps of:
a) providing a substrate having a generally flat surface,
b) placing two or more solder bumps having a predetermined volume on either the substrate or on the element, the bumps defining a single axis,
c) determining a shape, size and location of two or more solder pads on the other of the substrate or element so as to effect a predetermined orientation of the element at a predetermined angle with respect to the substrate during heating and melting of the solder bumps,
d) effecting a contact of the element with the substrate via the solder bumps, such that the element is secured to and supported on the solder bumps only, and
e) after step (d) heating the solder bumps in the absence of any further supporting or orienting of the element to cause a flow of the solder bumps and to cause a predetermined tilting displacement of the element by gravity forces and by surface tension forces substantially about the axis defined by the solder bumps so as to orient the element at a predetermined angle between angles greater than 0 and less than 90 degrees with respect to the substrate by said heating alone.

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There is no description in the cited Helfinger et al. patent in which:
an element is contacted to and supported by a substrate via solder bumps (step d in claim 1 above) and then whereby
the element is self aligned or oriented in a predetermined desired orientation by heating solder bumps alone, in the absence of any further supporting, in dependence upon the shape, size and location of two or more solder pads on the other of the substrate or element such that gravity and surface tension forces in the presence of heating the solder bumps orients the element at a predetermined angle.

A thorough reading of Helfinger et al, reveals in accordance with FIG. 3 and the description in col. 3 that chips are preferably already set in place in a desired array with a vacuum chuck 37 so that the chips are held in place on the array place. Further on col. 3 at lone 34 the following text is found:

> "With reference to FIG. 4, the stencil mask 13 serving as a transfer plate is brought over the die array stencil mask 27 which is serving as an array plate, holding chips 31 in place. An annular shim 67 has been inserted between the two stencils to adjust the stencil-to-stencil gap equal to chip thickness. This could also be accomplished by other methods. The two support rings are aligned by means of pins 21 fitting into bores 23. Because of the alignment previously established between holes in stencil mask 13 and holes in array plate stencil mask 27, the holes of stencil mask 13 will fall on the top side of the chips 31. Thus, a vacuum chuck 57 may be used to lift the chips as vacuum in line 39 is released. Release of vacuum in line 39 is indicated by arrow 61 while the

application of vacuum to stencil mask 13 for lifting the chips is indicated by arrow 63. Once the chips are lifted, they are brought over the circuit board or substrate, as indicated in FIG. 5.

With reference to FIG. 5, stencil mask 13 serving as a transfer plate for chips 31 is brought over substrate 11, with vacuum being maintained on the vacuum chuck 57 through line 65. Alignment pins 21 will fit into corresponding bores in the alignment ring 43. An annular shim 67 has been laid over the alignment ring, with the shim thickness chosen to compensate for solder bumps, chip thickness and substrate thickness. Once the alignment pins are seated, solder bumps on the chips 31 will be in contact with the solder bumps on the substrate 11. Prior to bringing the chips into contact, however, flux is applied to exposed solder bumps. This may be done either by spraying flux onto the unmasked substrate 11, by spraying flux through another stencil mask, not shown, which is aligned below the chips 31 or above the substrate 11, by transfer from a flux-coated disc (not shown) onto the solder bumps on substrate 11, or by carefully dipping the solder bumps of the die array in a shallow pool of solder flux. After application of flux, the chips are brought into contact with the solder bumps by lowering the transfer plate. Vacuum is released from the transfer plate, as well as from the substrate; then the substrate is placed in an oven to fuse the chips onto the board."

It is clear from reading Helifinger, that the chips are held by vacuum onto a transfer plate in a predetermined position and then the transfer plate is sandwiched with the substrate so that the chips are held in position as shown, for soldering.

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A significant distinguishing factor between that of Helfinger and that of the instant invention is that in the instant invention a chip or element is first secured to a substrate in a first position. However, this is not the final position or orientation in which the chip is to remain with respect to the substrate. It is merely temporarily secured or tacked in place. By correctly choosing the pad shape, size and location, and applying heat after the chip is temporarily tacked or held, the chip re-orients itself to a predetermined orientation, by force of both gravity and surface tension forces. And in this manner the chip self-aligns with no further support or direction.

Helfinger merely holds it in a predetermined orientation while the bumps are melted. This maintains the chip in the orientation in which it was placed. The goal in all of the prior art references is to sure the chip in the position in which it is held. The applicant purposely designs the pads so that the chip will move into a second predetermined position by said heating step alone.

The applicant's claim 1 in step e) defines:

after step (d) heating the solder bumps in the absence of any further supporting or orienting of the element to cause a flow of the solder bumps and to cause a predetermined tilting displacement of the element by gravity forces and by surface tension forces substantially about the axis defined by the solder bumps so as to orient the element at a predetermined

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angle between angles greater than 0 and less than 90 degrees with respect to the substrate by said heating alone.

Helfinger does not heat in the absence of further supporting to cause a predetermined tiling displacement at a predetermined angle between 0 and 90 degrees.

In fact Helfinger teaches away from the applicant's invention by ensuring the chip is firmly held in a fixed orientation while melting the solder.

By carefully designing the pads to be a correct shape, size and be at a preferred location, the chips after being securely supported in place re-orient themselves by heating alone with no further supporting or guiding to cause a predetermined tiling displacement. This is a significant advantage and cost savings when manufacturing circuit boards. No further intervention is required.

United States patent number 6,418,033 in the name of Rinne relates to and is entitled Microelectronic Packages in which Second Microelectronic Substrates are Oriented Relative to First Microelectronic Substrates at Acute Angles.

Rinne, in US Patent 6,418,033 teaches a way in which the packing density can be increased by stacking chips upon one another or adjacent to one another using solder bump technology.

The examiner states that "Rinne discloses the method of bonding an element to a substrate comprising the steps of

providing a substrate having a flat surface, placing two or more solder bumps on either the substrate or the element, providing means for asymmetrical flow of the solder bumps upon melting, effecting a contact of the element with the substrate via the solder bumps, and heating the solder bumps to cause a non uniform flow of the solder bumps and *a tilting displacement of the element substantially about the axis defined by the solder bumps."*

The applicant's claim 1 is a method claim, which defines method steps (a through e).

Rinne certainly does not teach steps:

d) effecting a contact of the element with the substrate via the solder bumps, such that the element is secured to and supported on the solder bumps only, and

e) after step (d) heating the solder bumps in the absence of any further supporting or orienting of the element to cause a flow of the solder bumps and to cause a predetermined tilting displacement of the element by gravity forces and by surface tension forces substantially about the axis defined by the solder bumps so as to orient the element at a predetermined angle between angles greater than 0 and less than 90 degrees with respect to the substrate by said heating alone.

In fact Rinne teaches away from this by ensuring that subsequent heating does not alter the position of the chip to be bonded.

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In Fig. 1 of Rinne there is no evidence that the shape, location and size of the pad in combination with surface tension force and gravity alone changes the orientation of the chip. It is the applicant's contention that Rinne supports the chip 120 as was always done in chip bonding applications. He does not teach or suggest a process in which the chip will self align or self orient itself. In fact, Rinne make the following comment which indicates that support is required.

"Microelectronic packages of FIG. 3 may be fabricated according to embodiments of the present invention by orienting the integrated circuits 320, solder bumps 330 and integrated circuit mounting substrate 310, as shown in FIG. 3, and reflowing the solder. Prior to reflowing the solder, the last (rightmost in FIG. 3) integrated circuit 330 may need to be supported so that it does not fall. The other integrated circuits also may need to be supported."

Clearly Rinne's invention depends upon supporting the chip to be soldered into place. Rinne is clear that even chips that have already been soldered in place may need to be supported when subsequent chips to be soldered are heated.

In other embodiments, Rinne uses the substrate as a stopper to determine the angle at which the chip will be; and in Fig. 6 where chips are piggy-backed one supports the other determining the angle at which that chip will rest with respect to the substrate.

The examiner in the office action stated that:

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"Rinne discloses in his method providing means for asymmetrical flow of the solder bumps upon melting, effecting a contact of the element with the substrate via the solder bumps, and heating the solder bumps to cause a non uniform flow of the solder bumps and *a tilting displacement of the element substantially about the axis defined by the solder bumps.*"

Nowhere does Rinne disclose

e) after step (d) heating the solder bumps in the absence of any further supporting or orienting of the element to cause a flow of the solder bumps and to cause a predetermined tilting displacement of the element by gravity forces and by surface tension forces substantially about the axis defined by the solder bumps so as to orient the element at a predetermined angle between angles greater than 0 and less than 90 degrees with respect to the substrate by said heating alone.

Rinne doesn't support or tack his element and further heat to cause a predetermined orientation in the absence of any further support. This is simply not taught.

Rinne heats and supports his element relative to his substrate at a predetermined angle. This is clear from his specification. There is simply no teaching of providing pads of a predetermined shape size and location and heating the solder bumps alone to achieve the angle of θ without any further support so as to cause a predetermined tilting displacement.

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Both Rinne and Helfinger perform convention solder bump techniques in supporting the element that is being soldered with respect to the substrate it is to be oriented on.

In the office action, the summary remarks in the last paragraph state that it would have been obvious to one of ordinary skill in the art at the time applicant's invention was made to provide the acute angle bonding taught by Rinne, with Helfinger et al's method for the purpose of elimination of solder flow expansion during reflow.

The applicant simply doesn't understand this statement. Helfinger et al. never mention the term "solder flow expansion" and the only reference to reflow is the following sentence: "Unusual skill was required to serially place a large array of chips on a board in a short enough time that the solder flux did not dry out before the assembly could be placed in an oven for solder bump reflow to complete the joinder process."

Helfinger's use of reflow is simply the notion of creating solder bumps and then reflowing them when the chip is firmly held in place for joinder.

Notwithstanding, the applicant does not understand how this relates to the claimed invention.

Applicant's claim 1 provides method steps which include:

> c) determining a shape, size and location of two or more solder pads on the other of the substrate or element so

as effect a predetermined orientation of the element at a predetermined angle with respect to the substrate during heating and melting of the solder bumps,

d) effecting a contact of the element with the substrate via the solder bumps, such that the element is secured to and supported on the solder bumps **only**, and

e) after step (d) heating the solder bumps in the absence of any further supporting or orienting of the element to cause a flow of the solder bumps and to cause a predetermined tilting displacement of the element by gravity forces and by surface tension forces substantially about the axis defined by the solder bumps so as to orient the element at a predetermined angle between angles greater than 0 and less than 90 degrees with respect to the substrate by said heating alone.

Neither Helfinger et al. or Rinne, teach choosing a shape, size and location of solder pad so as to effect a predetermined orientation in the presence of heat. Regardless of the shape and size of their pad, they use the conventional technique of holding the element in a fixed position during soldering.

Neither Helfinger or Rinne perform steps (d) and (e) where the element is first contacted such that it is supported only by the solder bump in a first position, followed by heating in the absence of further supporting to cause a flow of the solder bumps and to cause a predetermined tilting displacement of the element by gravity forces and by surface tension so as

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to orient the element at a predetermined angle at a second different position.

The applicant would like to make abundantly clear the fact that this invention relies upon first securely supporting the element or chip in a first position (step d) so that the chip is securely held.

In the instance where there are only two bumps provided, this allows the chip or element to be suspended and supported by the solder bumps without the chance of the element falling to one side or the other, as in a see-saw; in this instance the chip is first tacked to the substrate via the solder bumps.

Once the chip is supported and held without any further support, step (e) can occur, wherein the solder is heated and the chip pulls itself into a predetermined second position due to the shape, size, and location of the pads and in the presence of gravity and surface tension forces alone.

In order to more clearly define the invention, the applicant has amended the claim as follows.

> 1. A method of bonding an element to a substrate, the method comprising the steps of:
> a) providing a substrate having a generally flat surface,
> b) placing two or more solder bumps having a predetermined volume on either the substrate or on the element, the bumps defining a single axis,
> c) determining a shape, size and location of two or more solder pads on the other of the substrate or element so

as effect a predetermined orientation of the element at a predetermined angle with respect to the substrate during heating and melting of the solder bumps,

d) effecting a contact of the element with the substrate via the solder bumps, such that the element is ~~secured to and~~ supported on the solder bumps only in a first supported position, and

e) after step (d) heating the solder bumps in the absence of any further supporting or orienting of the element to cause a flow of the solder bumps and to cause a predetermined tilting displacement of the element by gravity forces and by surface tension forces substantially about the axis defined by the solder bumps so as to re-orient the element at a predetermined angle in a second secured position between angles greater than 0 and less than 90 degrees with respect to the substrate by said heating alone.

Claim 9 has been amended as follows:

9. The method of claim 1 wherein ~~the element comprises an opto-electronic component.~~ the step of effecting a contact of the element with the substrate via the solder bumps includes the step of heating the solder so that the element is tacked to the solder and supported in the first supported position.

The applicant contends that none of the prior art references first support the element securely upon the solder bumps without any further holding or supporting other than the element alone being supported by the solder bumps; and

subsequently, heating the solder bumps to re-orient the element in a predetermined position in dependence upon the shape, size and location of the solder pads in the presence of gravity and surface tension forces.

All of the prior art specifically teaches non-reorientation after the solder is heated, since the chip is held in a fixed position. And there is certainly no teaching of re-orienting in a predetermined position in dependence upon the shape, size and location of the solder pads in the presence of gravity and surface tension forces.

This invention cleverly uses the shape, size and location of pads and the forces of gravity and surface tension to move and re-orient the chip so that is self aligns from one position to another in a predetermined manner by heating alone.

There is no suggestion of this in any references.

In view of the above comments the applicant believes that amended claims 1 and 9, claims 2-8, 11-17 and 20 pending in this application are in condition for allowance.

Early and favorable reconsideration of the Examiner's objections would be appreciated.

Should any minor informalities need to be addressed, the Examiner is encouraged to contact the undersigned attorney at the telephone number listed below.

Please charge any shortage in fees due in connection with the

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filing of this paper, including Extension of Time fees, to Deposit Account No. 50-1465 and please credit any excess fees to such deposit account.

Respectfully submitted,

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CERTIFICATE OF FACSIMILE TRANSMISSION

I HEREBY CERTIFY that the foregoing correspondence has been forwarded via facsimile number **703-872-9306** to MAIL STOP AMENDMENT, COMMISSIONER FOR PATENTS, this 20 day of June 2005.

I. Kallemeyn